2. "There is another way in which the fertility of the soil can be maintained, viz., by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop."—U. S. Farmers' Bulletin (1906) 257, p. 21.

3. "The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that can not be exhausted; that can not be used up."—Bureau of Soils Bulletin (1909) 55, p. 66.

4. "From the modern conception of the nature and purpose of the soil it is evident that it can not wear out, that so far as the mineral food is concerned it will continue automatically to supply adequate quantities of the mineral plant foods for crops."—Bureau of Soils Bulletin (1909) 55, p. 79.

If again we turn from theory to science, we find at the Rothamsted Station in a four-year rotation, including always a legume crop, that the yield of turnips decreased from 10 tons in 1848 to less than 1 ton per acre as an average for the last 20 years; that the barley decreased from 46 bushels in 1849 to 14 bushels as an average for the last 20 years; that the clover has decreased from 2.8 tons per acre in 1850 to less than one half-ton average since 1890; and that the wheat produced 30 bushels in 1851, and 33 bushels average during the next 12 years, but only 24 bushels since 1890, and 20 bushels per acre since 1900.

As an average of the last twenty years the value of the four crops on the unfertilized land at Rothamsted is $33.83 (from four acres), but where the same crops were grown on adjoining land to which mineral plant food had been applied the average value is $76.83, the increase being 140 per cent. above the cost of the minerals. Let us thank God for Rothamsted, and be grateful that agriculture has some facts.

Likewise at State College, a four-year rotation, including clover, has been practised for nearly thirty years, but as an average of two consecutive 12-year periods the value of the four crops (corn, oats, wheat and hay) decreased from $44.20 to $32.72; but where mineral plant food was applied the crop yields averaged 49 per cent. above the unfertilized yields.

Both the teaching of science as applied to agriculture and the practise of farming, in America, have suffered and still suffer from an insufficient accumulation of facts and from an over-production of theories and conclusions.

While famine is frequent in China and Russia and almost constant in India—the only great populous agricultural countries comparable with the United States in necessary self-dependence—and while the beautiful level upland Leonardtown loam soils of southern Maryland, near the city of Washington, still lie agriculturally abandoned, with only 80 pounds of total phosphorus and 500 pounds of total calcium per million in the surface soil (facts discoverable even in Bureau of Soils Bulletin 54), shall we encourage the Whitney-Cameron doctrine[3] *that it is never necessary at any time to introduce fertilizing material into any soil for the purpose of increasing the amount of plant food in that soil?*

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Brownian Movements and Molecular Reality

To the Editor of Science: I have recently received a copy of Mr. F. Soddy's English translation of Professor Jean Perrin's paper on "Brownian Movements and Molecular Reality." Its perusal recalls to mind some ideas I have entertained for a number of years relative to a general physical theory based on very simple facts or principles. The earliest record I have of these ideas is in a memorandum note of November 10, 1897. In a letter of January 30, 1900, to Professor Peter S. Michie, of the department of philosophy, U. S. Military Academy, West Point, the ideas referred to were outlined rather more clearly and I also presented a brief statement of them under date of August 11, 1900, to the International Congress of Physics which was held at Paris in connection with the Universal

[3] Hearings before the Committee on Agriculture of the United States House of Representatives (1908), page 446; or Ginn & Company's "Soil Fertility and Permanent Agriculture," page 315.

Exposition of that year. A brief paper on the subject was presented to the American Physical Society in 1903, and an abstract of this paper was published in the *Physical Review* for April, 1903, but the complete paper with diagrams has not been published. The title of the paper was "A Simple Geometrical Principle and its Possible Significance in Connection with a General Physical Theory," and the principle referred to was stated as follows:

In an aggregation of an indefinite number of equal spherical bodies an arrangement giving minimum total volume and perfect symmetry throughout is impossible.

Three different arrangements of a group of spherical balls of equal size were considered: arrangement A, in which twelve of the balls are grouped about a central one, so the surrounding balls are tangent to the central one and to each other throughout; arrangement B, in which twelve balls are symmetrically disposed about and touch a central one, but nowhere touch each other, and arrangement C, in which the balls have the cubical arrangement, or the one in which the mutually tangent planes form cubes. The following is quoted from the published abstract referred to above:

The assumption is now made that the balls come together in a collection under their mutual attractions according to gravity laws. They will not assume or remain in arrangement C because while this gives symmetry throughout it is not the most compact possible and the equilibrium of the collection would be unstable.

Arrangement A, while the most compact possible for an indefinite number of balls in contact throughout, is not entirely symmetrical.

Arrangement B gives a perfectly symmetrical disposition of twelve balls with respect to a central ball but it is geometrically impossible throughout a collection of a greater number than thirteen.

It is suggested that under the conditions assumed the result will be that the balls will assume no fixed arrangement, but that they will be in continual relative movement, striving after the unattainable arrangement that will give minimum total volume, symmetrical disposition, and therefore fixed stable equilibrium throughout.

So far as I can now recall, I had not learned of the Brownian movements at that time. I certainly did not have this phenomenon in mind when the paper was written. I have not been able to make out that Professor Perrin's paper contains any very clear explanation of or theory as to the underlying *cause* of the Brownian movements, or that it purports to suggest such an explanation or theory, but the relations between the actual phenomenon as described and the above quoted speculation seemed to me rather striking.

In my mind the Brownian movement paper tends to confirm the idea that the "simple geometrical principle" above described is deeply significant, if it is not indeed a general and fundamental principle of physical phenomena.

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FURTHER EARLY NOTES ON THE TRANSMISSION BY FLIES OF THE DISEASE CALLED YAWS

I HAVE previously published in SCIENCE[1] two notes on the transmission of this tropical disease by flies. The earlier reference bears date of 1769 from Guiana. The second, while of much later date (1817), indicates that in Brazil at that time the infection was conveyed by a certain fly recognizable by its small size.

Shortly after the publication of this second note, I received a letter from Professor J. B. Woodworth, leader of the Shaler Memorial Expedition to Brazil in 1908–09, in which he kindly called my attention to a further account of this phenomenon in Walsh's "Notices of Brazil." While spending the recent holidays at Washington at work in the Library of Congress, I looked up this reference and also found another and earlier statement. Believing that these accounts may not be devoid of interest and value, they are herewith reproduced.

The one referred to by Professor Woodworth is found in "Notices of Brazil in 1828 and 1829," by R. Walsh, published in Boston in 1831. On page 224 of volume I. we read:

A disease, called in the country *bobas*, is frequently attended with fearful consequences. It

[1] January 7 and November 4, 1910.